

At this time, it may be postfinished after generally forming the film on the substrate, or a screen, mold, or mask might be set on the substrate so as to form a piezoelectric/electrostrictive film element of desired type.

It is preferable to form the piezoelectric/electrostrictive film element
5 with a thickness of 1-100 μm , and more preferable to form it with a thickness of 5-30 μm .

The form piezoelectric/electrostrictive film is thermally treated to remove the remaining solvent and to convert the contained sol into fine ceramic particles. Thus the solvent is removed by thermal treatment and the ceramic sol
10 acts as a reaction medium on oxide particle surface to induce the bonding between ultrafine ceramic oxide particles.

The reason for the reaction, sufficient only by the thermal treatment at low temperature of 100-600°C, is that a reaction the same as a sintering may take place by mutual reaction of bonding between the ultrafine ceramic oxide
15 powder and the raw material of the constituent ceramic elements in the ceramic sol solution. So, the added organic materials are removed during the thermal treatment.

Specially in case of the polymeric organic compound, because the substrate may be damaged if thermally treated above 500°C, it is preferable to
20 treat it thermally at 100-300°C, when the polymeric organic compound is used as a substrate.

More preferably, thermal treatment may be conducted at 150-300°C, which temperature range can suitably secure the crystallinity and formability of the piezoelectric/electrostrictive film element, although the range is for the thermal
25 treatment at considerably low temperature.

The method mat further comprises a step of drying the formed piezoelectric/electrostrictive film element before the thermal treatment after forming the piezoelectric/electrostrictive film element, and it is preferable to dry the piezoelectric/electrostrictive film element at 70-100°C.

The piezoelectric/electrostrictive film element obtained by the method is excellent in characteristics proper for ceramics, although the element has been thermally treated at low temperature.

For the present invention as above, the energy required for electrophoretic deposition is reduced, because the ultrafine ceramic oxide powder is used and there is a low energization effect of the producing method, because the piezoelectric/electrostrictive film element can be formed when the stacking status of the particles is very dense even with only the thermal treatment at low temperature.

Now the present invention will be explained in detailed by the following practical examples. But the following application examples are only illustrations of the present invention and do not limit the extent of the present invention.

[Example 1]

1 g of fine powder PZT-PMN was added into methoxyethanol 300 ml and acetyl acetone 20 ml, and 1 g of PZT sol was added into the mixed solution. Then, it was dispersed for 30 minutes by an ultrasonic generator. Afterwards it was agitated by a magnetic stirrer.

A SUS 316L plate fixed to the silicon substrate and mask was prepared as a work electrode and a SUS plate of the same area was prepared as an opposite charge electrode. The electrodes were put into the suspension and were connected to an electric supply to produce electrophoretic deposition at 70 V and 0.03 A for 10 minutes.

The work electrode treated by vapor deposition was withdrawn, the substrate was separated from the SUS plate, and the mask was removed.

The substrate portion where a pattern had been formed was thermally treated at 100°C in a chamber and was dried, and was then thermally treated at 300°C, for 2 hr. Then aluminum was vapor deposited as an upper electrode, and

electric potential was applied to measure the displacement of the substrate (vibration plate) by piezoelectric phenomenon.

The piezoelectric characteristics represented by the displacement of the vibration plate were excellent and better than those of a piezoelectric/electrostrictive film element produced by the conventional method.

[Example 2]

1 g of fine powder PZT-PMN was added into methoxyethanol 300 ml and acetyl acetone 100 ml, into which mixed solution, 4 g of PZT sol was added. Then it was dispersed for 30 minutes by a ultrasonic generator. Afterwards it was agitated by a magnetic stirrer.

A SUS 316L plate fixed to a nickel substrate and a mask was prepared as a work electrode and a SUS plate of the same area was prepared as an opposite charge electrode. Then the electrodes were put into the suspension and were connected to an electric supply to produce electrophoretic deposition at 70 V and 0.03 A for 10 minutes.

The work electrode treated by vapor deposition was withdrawn, the substrate was separated from the SUS plate, and the mask was removed.

The substrate portion where pattern had been formed was thermally treated at 70°C in a chamber and was dried, and was then thermally treated at 300°C, for 2 hr. Then gold was vapor deposited as an upper electrode, and electric potential was applied to measure the displacement of the substrate (vibration plate) by piezoelectric phenomenon.

Piezoelectric characteristics represented by the displacement of the vibration plate were excellent and better than those of a piezoelectric/electrostrictive film element produced by the conventional method.